
Appendix A: Derivation of traffic procedure

Derivation of traffic procedure

Use the method described in “Detailed traffic procedure” on page 86 when there is a predetermined Erlang per portable rate for your site. For a description of the other traffic methods, see “Determining the number of Base Stations per cell” on page 37.

Basic traffic procedure

The traffic procedure used to derive the table on page 37 is based on the following parameters:

- A link uses the nearest cell center more than 99.5 percent of the time.
- The system locates users in the cell of their office 70 percent or more of the time. Conversely, the system locates users in another cell of the system 30 percent or less of the time.
- The average user with a desk telephone uses their portable less than 0.07 Erlangs per portable during the busiest hour of the day.
- The average user without a desk telephone uses their portable less than 0.15 Erlangs per portable during the busiest hour of the day.
- The Engset traffic forecasting model is used to determine the required number of Base Stations because the number of users in a Companion cell is relatively small. Conversely, the Erlang B traffic forecasting model is based on an infinite number of portables in a cell.

- A user without an office has equal probability of making or receiving a call in any cell.

The number of Base Stations required for each cell is based on the probability of locating each possible number of users, from no users through to the total number of users, using an anticipated number of portables per cell.

Detailed traffic procedure

To more precisely plan your site, use Table 18 to determine the number of portables a cell can support (the anticipated portable value) given the number of Base Stations and the Erlangs per portable. Table 18 is derived from Figure 36.

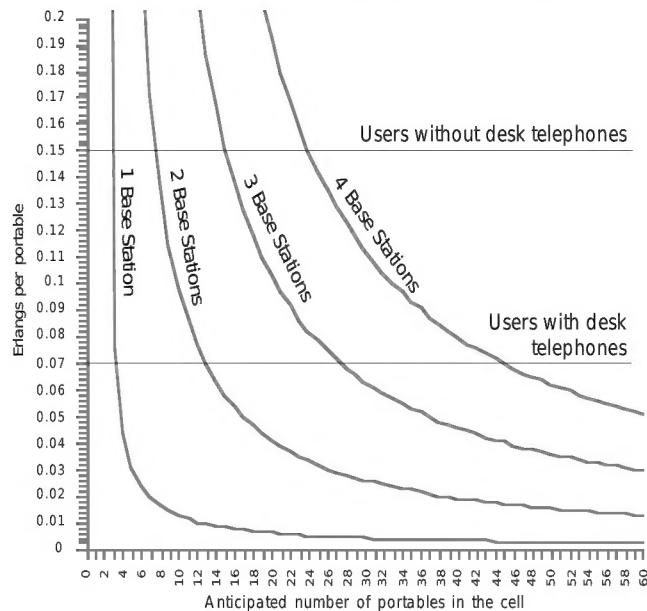
Table 18: Anticipated number of portables per cell

		Erlangs per portable				
		0.03	0.07	0.11	0.15	0.19
Number of Base Stations	1	5	3	2	2	2
	2	27	12	10	7	6
	3	59	27	18	15	12
	4	96	44	30	23	20

Use Figure 36 to determine

- the number of portables (the anticipated number of portables per cell) a cell can support given a particular number of Base Stations and a number of Erlangs per portable
- the maximum number of Erlangs per portable given the number of Base Stations and the number of portables in a cell
- the number of Base Stations required given the number of portables in the cell and the Erlangs per portable

Figure 36: Erlangs per portable versus portables in the cell



Appendix B: Using indoor external antennas

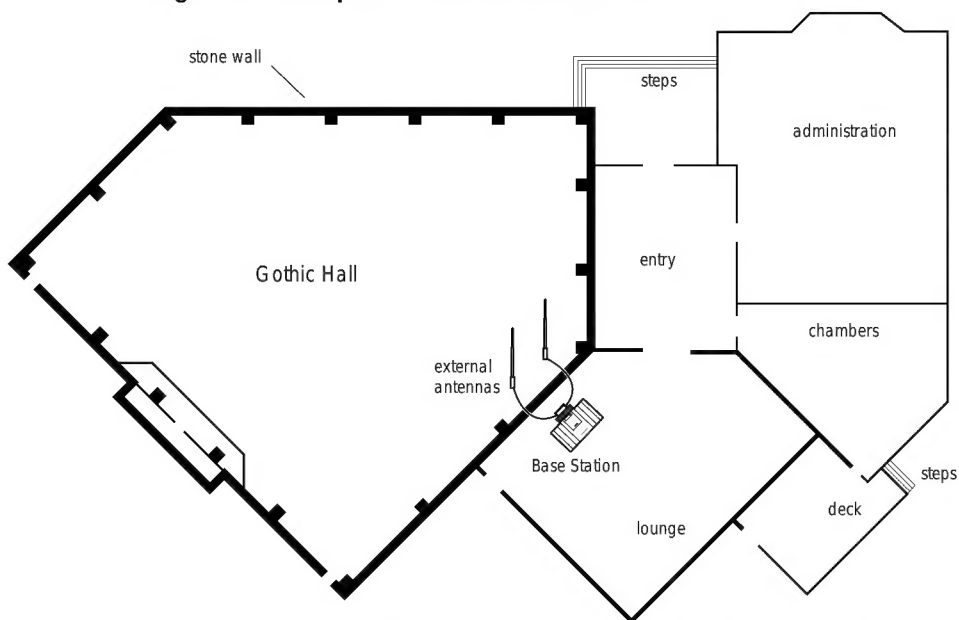
Selecting the appropriate indoor antenna

Use indoor external antennas to cover indoor areas when the following conditions are met:

- you require coverage on the side of a strong radio barrier where you cannot place a Base Station
- because of a strong radio barrier, a Base Station cannot provide coverage in the required area

For example, Gothic Hall requires coverage but is enclosed by a stone wall. Base Stations cannot be installed inside Gothic hall. Because of the stone wall, a Base Station installed in either the entry or the lounge will not serve the entire Gothic Hall. Indoor external antennas should be used in Gothic Hall.

Figure 37: Example of indoor external antenna



Select the appropriate antenna pattern of indoor external antenna based on the following guidelines:

Table 19: External antenna use

Type of antenna	Antenna pattern	When to use
Indoor external antenna ¹	omnidirectional	when coverage is required all around the antenna
	directional	when coverage is required only on one side of the antenna

1. All the indoor external antennas at a cell center must have the same pattern.

For each cell center requiring indoor external antennas, it is best to plan for two, four, six or eight indoor external antennas. Connect each pair of indoor external antennas at a cell center to the same Base Station.

If you connect only one radio to an external antenna serving the same cell center, it is best to disconnect the other radio. If, with external antennas, you have two radios in the same Base Station serving different cells, users in the area could have poor audio links and could drop their calls.

Simulating indoor external antennas with the CDT

Use one of the following methods to plan a cell requiring external antennas.

Using coaxial cable and an external antenna

Use this method when an external antenna and coaxial cable are available for planning.

When using a CDT transceiver with the coaxial cable and external antenna, set the CDT to external antenna and a cell boundary value of 6 dB higher than the value given in Table 4 on page 19. For example, -67 dBm is 6 dB higher than -73 dBm. The additional 6 dB is required because external antennas do not have antenna diversity.

For more information on this method, see “Base Stations” on page 5.

Changing the cell boundary value

Use this method when the external antenna and cable are not available for planning.

Calculate a new cell boundary value from the antenna’s gain, the coaxial cable’s loss, and the cell boundary value given in Table 4 on page 19. Set the

CDT to internal antenna and use the following formula to calculate the new cell boundary value:

$$\text{cell boundary value} + 6 + (0.7 \times \text{cable length in meters}) - \text{antenna gain}$$

Table 20: External antenna gain

Type of antenna	Antenna pattern	Antenna gain
indoor external antenna	omnidirectional	0 dB in all directions
	directional ¹	3 dB in direction of beam; 0 dB at right angles to direction of beam

1. The direction of the beam is perpendicular to and outward from the mounting surface.

Example

You require 33 ft (10 m) of RG 58/U coaxial cable for each indoor omnidirectional antenna. The area is indoors and there are no offices in the cell.

From Table 4 on page 19, the cell boundary value for no office indoors is -73 dBm. You determine

$$-73 + 6 + (0.7 \times 10) - 0 = -60 \text{ dBm}$$

You set the CDT transceiver to the internal antennas, and set the cell boundary value to -60 dBm.

Note: Use indoor external antennas only if you are unable to cover the area with a CDT transceiver located in an area where you can install Base Stations.

Appendix C: Fading

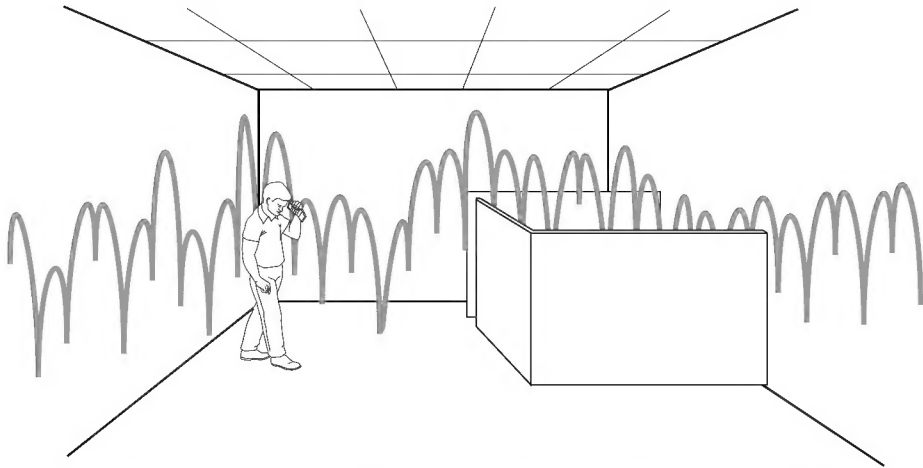
Fading

Fading causes a signal to vary in strength from good in one moment to poor in the next moment. When the signal is poor it is considered to be in a “fade.” The length of time that a fade persists can vary from as little as milliseconds to as much as several seconds.

A slight change in position of the portable can produce great variations in signal strength. The signal strength change is random, and frequently drops 5 to 15 dB below average. Fading is more severe for someone staying in one place than for someone walking. The person staying in place could have their portable in a faded area for longer periods. The person walking passes quickly through the fades.

The signal strength in a small room can vary greatly across the width of the room. As shown in Figure 38, the room is full of constructive and destructive patterns due to the signal traveling through the building and reflecting in many directions.

Figure 38: Constructive and destructive signal patterns



A constructive pattern raises the signal strength above average. A destructive pattern lowers the signal strength below average. The distance between a constructive and a destructive pattern spans only a quarter wave length of the signal. For frequencies around 900 MHz, a quarter wave length is 3 to 3½ in. (8 to 9 cm). For frequencies at 1.9 GHz, a quarter wave length is only 1½ in. (4 cm).

Walking briskly when taking measurements minimizes the effects of fading and gives a more accurate average signal strength.

A quick audio check that indicates an acceptable level of service in a particular area does not necessarily mean that the signal quality will consistently remain at that level. Because of fading, the audio quality in any area can change from moment to moment.

Appendix D: Key planning concepts

Key planning concepts

An efficient Companion system depends on the following planning concepts:

- synchronization
- power control
- Base Station and cell relationships
- portable originated call
- system originated call
- hand-off

Synchronization

When the portable transmits, the Base Station receives, and when the Base Station transmits, the portable receives. In all systems, all portables transmit and all Base Stations receive at the same time. One millisecond later, all portables receive and all Base Stations transmit at the same time. This synchronization allows you to put Base Stations together at a cell center.

Because of synchronization when one portable transmits none of the other portables receive it because they are transmitting (as shown in figure Figure 39), and when one Base Station radio transmits none of the other Base Station radios receive it because they are transmitting (as shown in figure Figure 40).

Figure 39: Base Stations receiving, portables transmitting



Figure 40: Base Stations transmitting, portables receiving



Other key planning concepts, for example power control and hand-off, depend on synchronization to function optimally.

Power control

Power control determines the transmission power of the portable. The portable transmits in either high or low power. Low power is approximately 16 dB lower than high power. The strength of the radio power does not affect the volume or loudness of the sound that the user hears.

Portables

All portables within a cell appear to be at different distances to a Base Station.

A Base Station radio signals nearby portables to go to low power for the benefit of the other Base Station radios at the same cell center. The other Base Station radios need nearby portables to transmit in low power so they can hear more distant portables.

When the Base Station radio perceives a weak signal strength, because the portable is far away, the Base Station radio signals the portable to transmit in high power.

Base Stations

All Base Station radios at a cell center appear to be the same distance away from a portable. Because of this common distance, Base Stations remain in high power.

A portable receives all the Base Station radios at the same cell center at approximately the same signal strength. Since none of the signals are stronger than the rest, the portable can discern the signal that it needs, whether the signal from the Base Station is weak or strong.

Optimizing power control

- Position Base Stations close together at cell centers.
- Keep different cell centers apart from each other.
- Do not plan to install Base Stations individually throughout the coverage area.
- Each cell center should have enough Base Stations to handle the traffic for the cell. Do not plan cells to depend on neighboring cells to handle extra traffic.
- Do not use overlapping systems.

Base Station and cell relationships

After the installer starts a Companion system, the system requires the following site-specific information:

- which Base Stations are in each cell center
- total number of cell centers
- which cell centers are adjacent neighbors
- which cell centers are radio neighbors

For systems using CT2Plus and PCI protocols, the system determines the Base Station and cell relationships by auto administration.

Auto administration

If planned properly, the auto administered cells are the same as the planned cells.

Note: Auto administration does not plan the system into cell centers. It allows the system to learn what the site planner has done. You are responsible

for planning the system into cells with cell centers. If you do not plan the system properly, auto administration cannot correct your mistakes.

Optimizing auto administration

- All Base Stations or external antennas in a cell must be as close together as possible at the cell center.
- Keep different cell centers apart from each other.
- Do not put a barrier (such as a large concrete or marble column, or a concrete wall) between Base Stations at a cell center.
- Stagger cell centers on adjacent floors.
- Use the left-right-skip method to plan multi-floor sites.
- Do not spread Base Stations throughout the coverage area.

Portable originated calls

Figure 41: Portable originated call



The portable requests a link on one of the 100 kHz channels and hails the system's name. All Base Station radios throughout the system that are not handling calls monitor for a portable originated call. These Base Station radios monitor one channel at a time, scanning repeatedly through all the channels. (Base Station radios scan independently of each other.)

Note: The first Base Station radio to tune into the channel that the portable is hailing on and to recognize the system's name, answers the portable. (This Base Station is not necessarily the one that is closest to the portable.)

Once the system establishes a link, and if the signal strength is below a threshold value, the Base Station radio requests a hand-off in case another cell center is closer to the portable.

For the PCI protocol, the link is set up with a Base Station radio at the same cell center as the signaling channel.

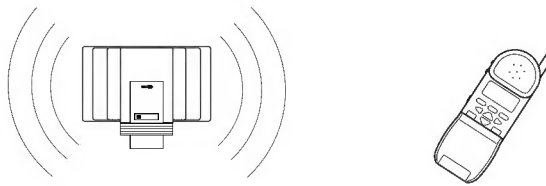
Optimizing portable originated calls

- Base Stations must be close together at the cell center.
- Cell centers should not be too close to each other.
- The -45 dBm contours of different cells should not overlap each other; however, a slight overlap is not serious.
- Use the left-right-skip method should to plan multi-floor sites.

System originated call

System originated calls are a result of calls presented to access lines.

Figure 42: System originated call



System

The system searches for the portable.

Note: The system notifies only one Base Station radio of an auto administered cell to hail the portable.

Portable

The portable is idle most of the time, but about once every second it monitors the signaling channel to see if there is a call. If there is a call, it establishes a radio link.

After the system establishes a link, the link is moved to the best radio for the link if the Base Station cell centers are not too close together (that is, the -45 dBm cell contours do not overlap).

Optimizing system originated calls

- Base Stations for a cell center should be close together.
- Base Station radios at a cell center should have exactly the same coverage.
- Base Stations at a cell center should not be too close to a concrete or marble column.
- Base Stations should be on the same side of a concrete or marble column.
- Cell centers should be kept apart from each other.
- The -45 dBm contours of different cells should not overlap each other; however a slight overlap is not serious.
- Use the left-right-skip method to plan multi-floor sites.

Hand-off

Hand-off occurs when an active radio link to a portable is transferred to another radio in the system. When a link is not connected to the closest available Base Station radio, or the user moves from one cell center to another, the system “hands off” to an available Base Station radio at a closer cell center.

Audio quality depends on keeping the distance between the portable and Base Station as short as possible. The Base Station radio requests a hand-off when there is any decrease in signal strength, no matter how slowly the decrease occurs. There is no absolute threshold at which the hand-off request is made. It is only important that the signal strength decreases.

The system waits for responses from the prospective Base Station radios and assigns the Base Station radio with the strongest signal strength to pick up the call.

The system requests only one Base Station radio in each of the adjacent cells and the radio neighbour cells to check the link.

Optimizing hand-off

- Cell centers must be far enough apart so that their -45 dBm contours do not overlap.
- Base Stations must be close together at the cell center.



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